

Acid Rain

Contents: A structured discussion about the problems of acid rain.

Time: 4 periods plus homework. This allows time for an audiovisual programme at the start. The total time needed will depend on the way in which the groups report on their conclusions.

Intended use: GCSE Biology, Chemistry and Science courses. Links with work on air pollution, fossil fuels, energy sources and acidity.

Aims:

- To complement and revise prior work on pollution, fuels, energy and acidity
- To outline the origins of acid rain and the problems associated with it
- To develop awareness of the complexity of the scientific, economic and environmental issues associated with pollution problems
- To encourage readiness to enter into discussion
- To provide opportunities to develop interpersonal and communication skills.

Requirements: Students' worksheets No. 902.

For each member of the class:

- 1 copy of General Briefing (sheets GB1 and 2)
- 1 copy of the Test (sheet T)

For each group of 5 students:

- 1 copy of each of the Expert's Briefings (sheets EB1, EB2, EB3 and EB4)
- 1 copy of the Chairperson's Briefing (sheet CB)

Some groups may need access to materials for producing a poster, OHP transparency or other means of explaining their chosen policy for dealing with acid rain. (See the final part of sheet CB.)

Author: Roland Jackson

This unit is best used after an audiovisual introduction. The SATIS Audiovisual production *Acid from the Air* might be used (see 'Other Resources').

The unit emphasizes the effects of acid rain on living things in lakes as well as on corrosion. There is little mention of the effect on trees because — at the time of writing — the experts disagree on the reasons for the death of trees.

The information in the briefings is presented in note form. Students have to put together the information to make a coherent statement. Encourage the groups to make positive suggestions and not just emphasize outrage and protest.

One of the problems in discussions of this subject concerns the definition of the term *acid rain*. Popularly it is used to encompass many different forms of air pollution which mostly have their origin in the combustion of fuels. The three most important are acid rain itself, gaseous sulphur dioxide and ozone. These types of pollution have to be distinguished because they differ in their origins, have different environmental effects and require different control measures.

Building decay is thought to be accelerated by high concentrations of sulphur dioxide in the air rather than by acid rain. High concentrations of sulphur dioxide used to occur near ground level in towns and cities where there were many local sources. Power stations contributed little to this problem. The solution was clean air legislation and the replacement of coal by natural gas and electricity for much domestic heating.

Cutting sulphur dioxide emissions from power stations is, however, appropriate in the case of long-range acid rain. Power stations produce two-thirds of the nation's output of sulphur dioxide.

Ozone may turn out to be important in the decline of forests. If so, the most probable effective action could be to reduce the emission of unburnt hydrocarbons from vehicles. The chemistry is complex: cutting the NO_x in exhausts might lead to *higher* levels of ozone pollution. Cutting down on oxides of nitrogen may reduce acid rain, though even this is not certain.

Procedure

- 1 Show an audiovisual programme to give students a picture of the problem.
- 2 Issue a copy of the General Briefing (sheets GB1 and 2) to each student and allow time for students to read it. This might be done for homework.
- 3 Get the students to do the test. This will take 10 to 15 minutes. Students might be allowed access to the General Briefing either while doing the test or when checking the answers.
- 4 Form the class into groups of five. Each group should have a Chairperson, chosen for his or her potential for leading a discussion.
- 5 Give the Chairpersons their briefing (sheet CB). Give Expert Briefings (sheets EB1, EB2, EB3 and EB4) to the other members of the group — a different sheet to each member. If the class does not divide neatly into groups of five, have some groups of six. Sheet EB1 is longer than the others and it may help if two students have studied it.
- 6 Allow time for the students to study their briefings.
- 7 Hand over the running of discussions to the Chairperson.
- 8 Encourage the groups to formulate a policy for dealing with acid rain. Finally each group should present a report on their conclusions in some appropriate form. Some groups may like to extend their discussion along the lines suggested by the following questions:
 - Even the experts disagree about the causes and effects of acid rain. Why is it so difficult to understand?
 - Why does it matter if no fish can live in rivers and lakes?
 - Why should we care if pollution from British power stations is killing the fish in the lakes of other countries?
 - How might our lives be affected if we decide to make a big effort to solve the acid rain problem?
 - Some people think that much more research needs to be done before we can make a sensible plan for tackling the acid rain problem. What would you say to such people?
 - What can each of us do to help solve the problem of acid rain?
 - Which of the methods of dealing with the acid rain problem are likely to be politically acceptable? Which are likely to be unacceptable?

Other resources

Videos/films

These two videos/films present contrasting views.

Acid rain — who cares? available on free loan as a 29-minute VHS video or 16 mm film from the Swedish Embassy, 11 Montague Place, London W1H 2AL.

Acid Rain available on free loan on VHS/Beta or 16mm film from CEGB Film and Video Library, Viscom Limited, Parkhall Road Trading Estate, London SE21 8EL.

Tape/slide sequences

SATIS Audiovisual, *Acid from the Air* (20 slides with a commentary), available from ASE.

Acid rain — the silent crisis (AVP 079) from the International Centre for Conservation Education, Greenfield House, Guiting Power, Cheltenham, Glos. GL54 5TZ.

Printed materials

Suggested sources:

There are regular articles about acid rain in newspapers and magazines including the *New Scientist*.

Ecology Party, 36/8 Clapham Road, London SW9 0JQ

Friends of the Earth, 26-28 Underwood Street, London N1 7JQ

Greenpeace, 36 Graham Street, London N1

National Society for Clean Air, 136 North Street, Brighton BN1 1RG

Central Electricity Generating Board, 15 Newgate Street, London EC1A 7AU (Department of Information and Public Affairs).

Acknowledgements Figure 2 (General Briefing) from *Acidification — a Boundless Threat to our Environment* (Swedish Ministry of Agriculture), reproduced by permission of the National Environmental Protection Board, Sweden; Figure 1 (Expert's Briefing 2) adapted from *Chemistry in Action Copymasters* (University of York Science Education Group); Figure 1 (Expert's Briefing 3) reproduced by courtesy of The British Petroleum Company, p.l.c.; Figure 1 (Expert's Briefing 4) supplied by courtesy of Lennart Henrikson.

ACID RAIN

General Briefing

What should we do about acid rain?

This is a controversial topic. No one is yet sure how much harm is done by acid rain. There are different theories to explain the effects of acid rain. Scientists disagree about the theories. Politicians are not sure that it is worth while spending large sums of money to solve a problem which is not properly understood.

You may see a film or be shown a tape-slide programme to give you a picture of the problems. You will study the information in this General Briefing and answer some questions in a short test. This will lead to a group discussion about possible ways of making rain less acid.

Where does acid rain come from?

- The pH of unpolluted rain is naturally about 5.0 because of dissolved gases including carbon dioxide. The pH of acid rain is lower than this, in the range 2 to 5.
- Coal and oil contain sulphur. When these fuels are burned, the sulphur turns to sulphur dioxide. Sulphur dioxide reacts in the air and in clouds to form sulphuric acid. Sulphuric acid makes rainwater acid.
- Some important metal ores are sulphides, such as copper and lead sulphides. Sulphur dioxide is formed when the metals are extracted from these ores.
- Some sulphur dioxide enters the air naturally from volcanoes and the decay of dead plants. But in Europe about 90 per cent of sulphur dioxide in the air comes from artificial sources.

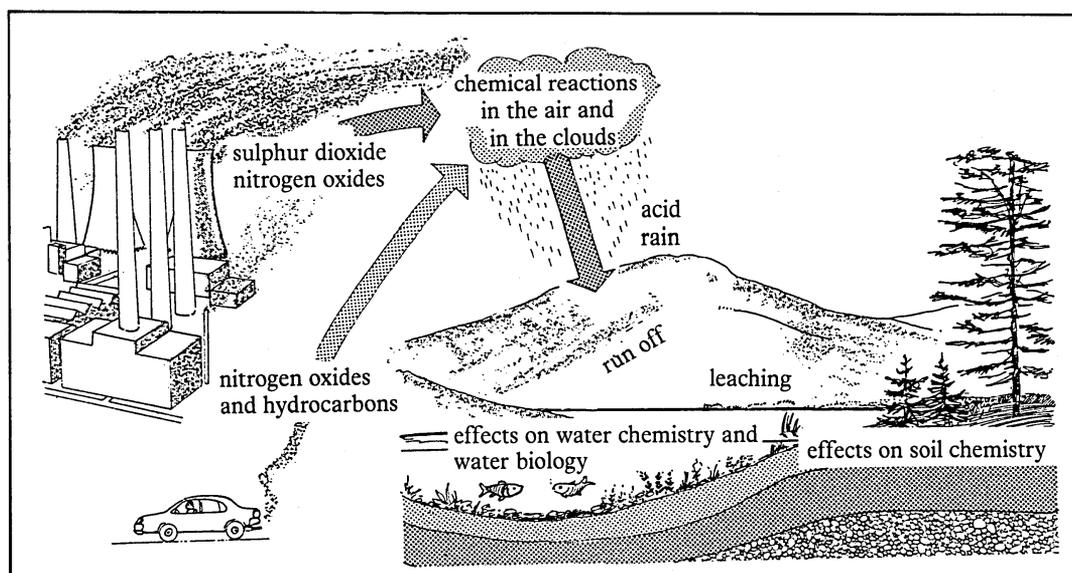


Figure 1

- Some sulphur dioxide enters the air naturally from volcanoes and the decay of dead plants. But in Europe about 90 per cent of sulphur dioxide in the air comes from artificial sources.
- The amount of sulphur dioxide given off in the UK fell by 37 per cent between 1970 and 1984 but the UK is still the largest producer of sulphur dioxide in Western Europe.
- About a third of the sulphur dioxide given off in Britain is carried by the westerly winds to Scandinavia and other parts of Europe. The rest lands in Britain or on the sea.
- Burning fuels also produce oxides of nitrogen. Oxides of nitrogen help cause acid rain. Motor vehicles are the major producer of oxides of nitrogen. Power stations also produce a lot.

What are the possible effects of acid rain?

- Lakes in Scotland are affected by acid rain. Some are so acid that fish are dying.
- Living things may die if the pH in a lake falls below 5.
- 4000 Swedish lakes have no life in them. 16 000 Swedish lakes have little life.
- Norwegian stocks of arctic salmon are almost extinct. Over half the brown trout in Norway have died.
- Acid rain speeds up the corrosion of metals.
- Water supplies in parts of Scandinavia are now acid enough to corrode metals. They become contaminated with dissolved metals such as copper, zinc and cadmium. This makes the water taste foul and may be harmful to health.
- Many trees in Europe are dying. Some scientists say that this is due to acid rain. Other experts disagree and say that the damage is done by drought, disease or pests. Others think that different types of air pollution may be killing the trees.

Production of sulphur dioxide in Western Europe in 1982 (million tonnes)

Britain	4.2
West Germany	3.5
Italy	3.1
France	2.9
Spain	2.0

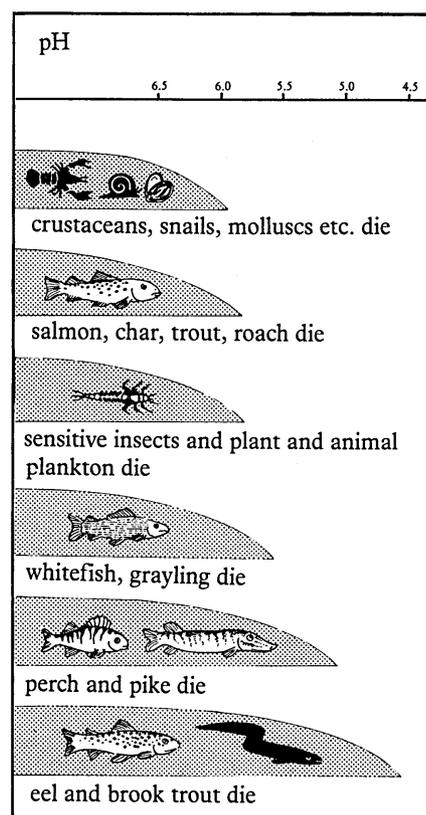


Figure 2

A test on acid rain

- 1 What are the natural sources of sulphur dioxide?
- 2 What are the artificial sources of sulphur dioxide?
- 3 Are the main sources of sulphur dioxide in Europe natural or artificial?
- 4 Why does sulphur dioxide make rainwater acid?
- 5 Which country in Western Europe produces most sulphur dioxide?
- 6 (a) Which gases, other than sulphur dioxide, help cause acid rain?
(b) Where do these gases come from?
- 7 Why is the acid rain in parts of Europe affected by what happens in other countries?
- 8 How does acid rain affect living things in lakes?
- 9 How does acid rain affect things made from steel?
- 10 Why is it hard to decide whether acid rain damages trees?

Expert's Briefing 1

Can we make rain less acid by cleaning up power stations?

You will shortly be taking part in a group discussion about acid rain. You will be trying to decide what you think should be done to cut down the problems caused by acid rain.

After you have read this briefing, the Chairperson of your group will be asking questions. You are the only one in your group who has read this sheet so you will be the expert on cleaning up air pollution from power stations.

When you, and the others in your group, have answered the questions you will try to decide what should be done about acid rain. You will try to think of constructive ways to solve the problem. As a group you will then prepare a short speech, or a leaflet or a poster to tell the rest of the class what you think should be done.

Information

- Coal and oil contain sulphur. When these fuels are burned the sulphur turns to sulphur dioxide. Sulphur dioxide reacts with air, other pollutants and water to form sulphuric acid. Sulphuric acid makes rainwater acid.
- Power stations release about two-thirds of the sulphur dioxide given off into the air in Britain. Most of the rest comes from industry.
- Sulphur can be removed from oil before it is burned. It is more difficult to remove the sulphur from coal.
- A process called 'flue-gas desulphurization' can remove the sulphur dioxide from the waste gases from power stations. Limestone is used to neutralize the sulphur dioxide.
- Fitting a flue-gas desulphurization plant would cost about £200 million pounds for a big power station. It would also cost about £30 million a year to run.
- Cutting down sulphur dioxide from all power stations could add about 10 per cent to electricity prices.
- The process for removing sulphur dioxide from power station flue gases uses limestone and produces calcium sulphate in a form which can be used to make plaster board for the building industry.
- Burning fuels in power stations produces oxides of nitrogen. Oxides of nitrogen help cause acid rain.
- Power stations release into the air about 40 per cent of the nitrogen dioxide emitted in Britain. Most of the rest comes from motor vehicles.
- The Central Electricity Generating Board are experimenting with new burners in power stations. The burners cut the production of oxides of nitrogen by a third. The cost of converting twelve power stations to the new burners was estimated to be £170 million in 1987. All large power stations will have new burners fitted during the next ten years.

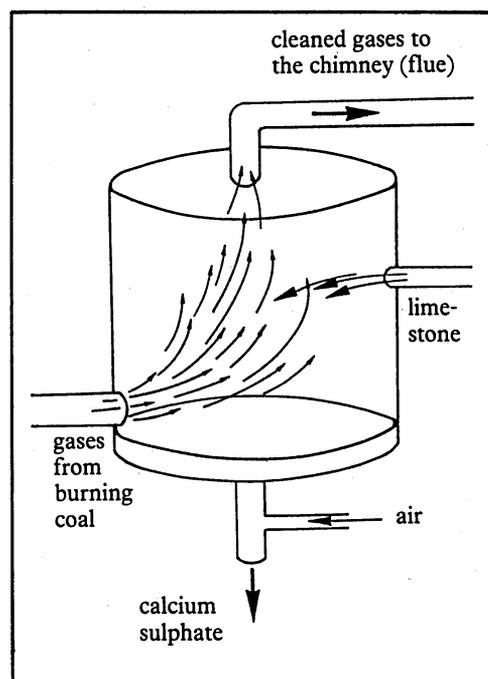


Figure 1 A simplified diagram to show how flue-gas desulphurization works

Expert's Briefing 2

Can we make rain less acid by cutting down pollution from motor vehicles?

You will shortly be taking part in a group discussion about acid rain. You will be trying to decide what you think should be done to cut down the problems caused by acid rain.

After you have read this briefing, the Chairperson of your group will be asking questions. You are the only one in your group who has read this sheet so you will be the expert on cutting down air pollution from motor vehicles.

When you, and the others in your group, have answered the questions you will try to decide what should be done about acid rain. You will try to think of constructive ways to solve the problem. As a group you will then prepare a short speech, or a leaflet or a poster to tell the rest of the class what you think should be done.

Information

- Burning fuels in vehicle engines produces oxides of nitrogen. Oxides of nitrogen help cause acid rain.
- Motor vehicles release into the air about 40 per cent of the oxides of nitrogen given off in Britain.
- Lower speed limits would help reduce the amount of oxides of nitrogen in vehicle exhausts. The percentage of nitrogen oxides in car exhausts falls from 0.11 per cent at 70 mph to 0.03 per cent at 30 mph.
- 'Lean-burn' engines have been designed which cut down the levels of nitrogen oxides in the exhaust to a quarter. These engines add about £30 to the cost of the car.
- Catalytic convertors can be fitted to cars. The catalysts cut down the amount of nitrogen oxides in the exhaust gases. Lead compounds stop the catalysts working.
- Cars with convertors have to run on lead-free petrol which costs more than ordinary petrol.
- A catalytic convertor costs about £500. It has to be replaced after the car has travelled 50 000 miles.

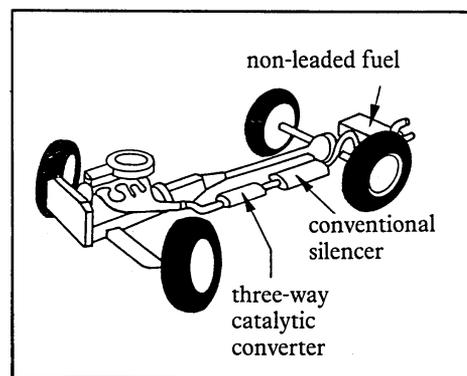


Figure 1

Expert's Briefing 3

Can we make rain less acid by cutting down on our use of fossil fuels?

You will shortly be taking part in a group discussion about acid rain. You will be trying to decide what you think should be done to cut down the problems caused by acid rain.

After you have read this briefing, the Chairperson of your group will be asking questions. You are the only one in your group who has read this sheet so you will be the expert on reducing acid rain by using less fuel.

When you, and the others in your group, have answered the questions you will try to decide what should be done about acid rain. You will try to think of constructive ways to solve the problem. As a group you will then prepare a short speech, or a leaflet or a poster to tell the rest of the class what you think should be done.

Information

- Coal and oil contain sulphur. When these fuels are burned the sulphur turns to sulphur dioxide. Sulphur dioxide reacts with air, other pollutants and water to form sulphuric acid. Sulphuric acid makes rainwater acid.
- Burning fuels in power stations and motor vehicles produces oxides of nitrogen. Oxides of nitrogen may help cause acid rain.
- We can cut down air pollution by using less energy. Saving energy means less fuel needs to be burned. Less coal will be burnt in power stations if we use less electricity .
- Nuclear power stations do not burn coal or other fuels so they do not emit oxides of nitrogen and sulphur.
- Developing wind power, solar power and hydroelectric power and other renewable sources of energy will produce electricity without adding to the acid rain problem.
- There would be fewer vehicles on the roads if more people used public transport.
- There would be fewer vehicles on the roads if more goods were transported by rail.

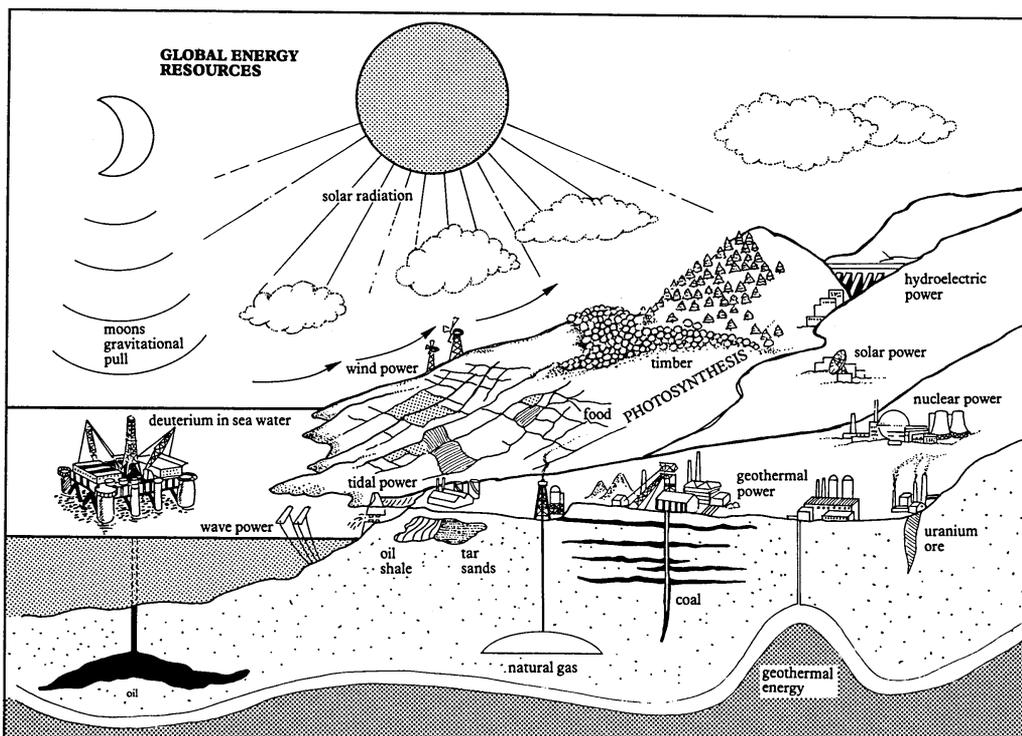


Figure 1

Expert's Briefing 4**Can we solve the acid rain problem by neutralizing the acids?**

You will shortly be taking part in a group discussion about acid rain. You will be trying to decide what you think should be done to cut down the problems caused by acid rain.

After you have read this briefing, the Chairperson of your group will be asking questions. You are the only one in your group who has read this sheet so you will be the expert on solving the problem by neutralizing the acids. When you, and the others in your group, have answered the questions you will try to decide what should be done about acid rain. You will try to think of constructive ways to solve the problem. As a group you will then prepare a short speech, or a leaflet or a poster to tell the rest of the class what you think should be done.

Information

- Limestone is calcium carbonate. Calcium carbonate does not dissolve in pure water but it neutralizes acids.
- Limestone can be converted to calcium hydroxide - slaked lime.
- Powdered lime can be spread on the soil to neutralize acidity. Farmers have used lime to control the pH of the soil for centuries.
- Adding limestone to lakes neutralizes the acidity.
- Some experts believe that the cheapest way to reduce the acidity of lakes is to dose them with limestone. Liming will cost less than changing power stations to cut down the sulphur dioxide they give off. The cost of liming lakes in Sweden is around £25 million per year.
- Liming has to be repeated regularly because lakes soon become acid again if liming stops.

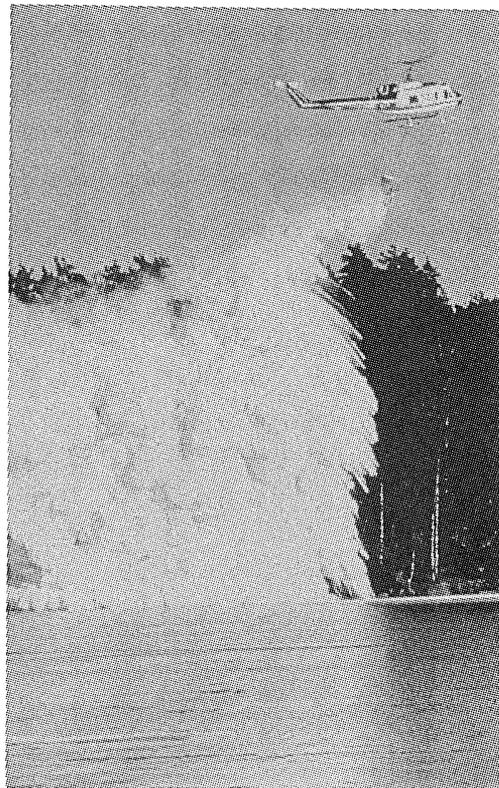


Figure 1 Spreading lime on a lake from the air

Chairperson's Briefing

You are the chairperson of a group of students. It is your job to ask questions and chair a discussion about acid rain. The point of the discussion is to examine possible ways of solving the problems caused by acid rain.

Much of the success of the session will depend on how well you do your job.

Everyone in your group will have read the General Briefing and they may also have watched a video or seen some slides. Each member (except you) will also have read an Expert's Briefing. The subjects of the expert briefings are listed in the box (right).

Begin by asking some questions about solving the problems of acid rain.

Subjects of Expert Briefings

- 1 Can we make rain less acid by cleaning up power stations?
- 2 Can we make rain less acid by cutting down pollution from motor vehicles?
- 3 Can we make rain less acid by cutting down on our use of fossil fuels?
- 4 Can we solve the acid rain problem by neutralizing the acids?

Suggested questions

- 1 What is acid rain?
- 2 How is acid rain formed?
- 3 How can air pollution from power stations be cut down?
- 4 What are the problems involved in dealing with air pollution from power stations?
- 5 They say we could cut down on air pollution by using other methods for generating electricity. Why?
- 6 How can air pollution from motor vehicles be cut down?
- 7 What are the problems involved in dealing with pollution from motor vehicles?
- 8 Are there any ways of reducing the acid rain problem which do not involve expensive changes to power stations and motor vehicles?
- 9 They say we could cut down acid rain by finding ways of burning less fuel. What are the problems involved in doing this?
- 10 They say we could deal with the problem by neutralizing the acids. How?
- 11 What are the problems involved in neutralizing the acids?

Group report

When your group has answered the questions try to get them to decide what should be done to solve the problem of acid rain. Encourage the group to come up with constructive ideas. Organise the group to prepare a short speech, or a leaflet, or a poster, to tell the rest of the class what you all think should be done.